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Original Article

EFFECT OF DRIP FERTIGATION AND PLASTIC MULCHING ON THE PLANT GROWTH AND YIELD ATTRIBUTES OF CHILLI (*Capsicum annuum* L)

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ABSTRACT

Field experiment was conducted in 2013 – 2014 at Precision Farming Development Centre research farm, Tamil Nadu Agricultural University, Coimbatore. To study the effect of drip fertigation and plastic mulching on the plant growth and yield attributes of chilli (Capsicum annuum L). The experiment were laid out factorial randomized block design which included three fertigation levels 80, 100, and 120 per cent Recommended Dose of Fertilizers (RDF) and three different mulching treatments 25, 50 micron Black Plastic Mulch (BPM) and no mulch which were replicated thrice. In chilli maximum yield of 128 numbers of fruits plant^{-1} which is worked out as 12.27 t ha^{-1} was observed for the treatments T_3. The total quantity of water applied uniformly to all the treatments was 75.83 litres as per the crop water requirement. Maximum water use efficiency observed in T_3 (66.36 kg ha^{-1}.mm^{-1}). The maximum N, P and K fertilizer use efficiency of 109.95 kg ha^{-1}, 164.94 kg ha^{-1} and 164.94 kg ha^{-1} respectively, were observed in T_1. The highest benefit cost ratio was recorded under both T_2 (BPM of 25 micron thickness with 100 per cent RDF) and T_3 (BPM of 25 micron thickness with 120 per cent RDF). From economic viability point the T_2 treatment registered results that were economically viable with highest profit. Increased yield in fertigation treatments might be due to better availability of plant nutrients and irrigation water throughout the crop growth period under drip fertigation system.

KEYWORDS: Green chilli, Drip Fertigation, Plastic Mulching, Green Chilli Yield and Benefit Cost Ratio

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INTRODUCTION

In recent trends in our nation, the irrigated area consists of about 36 per cent of the net sown area. Presently the agricultural sector accounts for about 83 per cent of all water uses. Increasing competition with the other water users in the future would be limiting the water availability for expanding irrigated area. Mark et al. (2002) reported that by the year 2025, 33 per cent of India's population will live under absolute water scarcity condition. The per capita water availability in terms of average utilizable water resources in the country was 6008 m^3 in 1947 and is expected to dwindle to 760 m^3 by 2025 (Kumar, 2003) .

Drip irrigation involves supplying water to the soil very close to the plants at very low flow rates (0.5 to 10 lph) from a plastic pipe fitted with outlets (drip emitters). Drip irrigation results in a very high water application efficiency of about 90 to 95 per cent. Fertigation has the potential to supply a right mixture of water and nutrients to the root zone, and thus meeting plants water and nutrient requirements in most efficient possible manner (Patel et al., 2001). With fertigation, water use efficiency of the crops has to be increased in order to reduce the water loss from the fields and nutrients use efficiency is increased and the loss of nutrients to the groundwater is reduced.

Mulching is the process or practice of covering the soil to make more favourable conditions for plant growth, development and efficient crop production. Black plastic mulch is used most widely because it slows down weed growth, resulting in less chemical usage, recorded the lowest number of weeds in black plastic mulch (Ashrafuzzamm et al., 2011). Black plastic mulch raise soil temperatures quickly, so the plants can increase growth resulting in earlier and higher yields (possibly up to 15 per cent or more) compared to bare ground production (Wallace et al., 1996). Vegetable production in Indian agriculture has wider scope for increasing the income of the marginal and small farmers. Vegetables have vast potential in gaining foreign exchange through the export. The vegetable growers are looking for new ways to achieve superior quality produce with higher yields. Among the vegetables grown, chilli is a spice cum vegetable crop of commercial importance.

MATERIALS AND METHODS

This paper present, **"Effect of drip fertigation and plastic mulching on the plant growth and yield attributes of chill**i**"** was carried out in PFDC research farm, Tamil Nadu Agricultural University, Coimbatore. The place is situated at 11^0 N latitude and 77^o E longitude with mean altitude of 426 m above the mean sea level. The proposed research work was laid out during 2013 to 2014 under irrigated condition, to study the effect of drip fertigation and plastic mulching on the plant growth, and yield attributes of chilli (COCH1) *(Capsicum annuum* L.*)* on sandy clay loam soil.

The experimental plot was thoroughly ploughed with disc plough and tilled twice with cultivator to bring optimum soil tilth. The length and width of the field is 15 m and 15 m respectively. The total area is divided into various strips of 4.5 m x 1.2 m according to the treatments. The spacing of 60 x 60 cm, recommended for chilli in the package of practice recommendation: crops Coimbatore Chilli Hybrid (COCH1) was adopted.

Design and Treatments

The experiment was laid out with nine treatments; combination consists of three fertigation treatments and three mulching treatments. The experiment was laid out in Factorial Randomized block design having nine treatment combinations and was replicated thrice. The treatment details are shown in Table 1.

Main Plots: Fertigation levels

F_1: 80 per cent of recommended dose of fertilizer

F_2: 100 per cent of recommended dose of fertilizer

F_3: 120 per cent of recommended dose of fertilizer

Subplots: Mulching treatments

M_1: Black plastic mulch of 25 micron thickness

M_2: Black plastic mulch of 50 micron thickness

M_3: Control (No mulch)

Table 1: Treatment Details

Treatments	Description
$T_1 M_1$	Black Plastic mulch of 25 micron thickness with 80 % RDF
$T_2 M_1$	Black Plastic mulch of 25 micron thickness with 100 % RDF

Table 1: Contd.,	
$T_3 M_1$	Black Plastic mulch of 25 micron thickness with 120 % RDF
$T_4 M_2$	Black Plastic mulch of 50 micron thickness with 80 % RDF
$T_5 M_2$	Black Plastic mulch of 50 micron thickness with 100 % RDF
$T_6 M_2$	Black Plastic mulch of 50 micron thickness with 120 % RDF
$T_7 M_3$	No mulch with 80 % RDF
$T_8 M_3$	No mulch with 100 % RDF
$T_9 M_3$	No mulch with 120 % RDF

Irrigation Water Quality

Quality of irrigation water is moderately saline. The water was analyzed for pH, EC, total alkalinity, Cl_2, SO_4, Ca, Mg, Na, K, SAR and soluble sodium percentage. The details of quality of irrigation water are presented in Table 2.

Table 2: Quality of Irrigation Water

Water Quality Parameters	Observed Values
pH	7.56
EC	1.93 dS m^{-1}
Bi-carbonate (HCO_3)	2.80 meq l^{-1}
Chloride (Cl_2)	24.00 meq l^{-1}
Calcium (Ca)	9.04 meq l^{-1}
Magnesium (Mg)	15.20 meq l^{-1}
Sodium (Na)	17.90 meq l^{-1}
Potassium (K)	0.36 meq l^{-1}
SAR (Sodium Adsorption Ratio)	5.37
SSP (Soluble Sodium Percentage)	36.35

Irrigation Scheduling

Irrigations were scheduled on the basis of climatological approach on mulch and control plots. Life saving irrigation was given immediately after transplanting and the field was regularly irrigated continuously for ten days. After the tenth day, subsequent irrigations were scheduled once in three days based on the following formula and applied each time as per the treatment schedule. The discharge rate of single dripper is 4 lph at a nominal operating pressure of 50.66 kpa. Time required for each irrigation is shown in Table 2.

$$WR_c = CPE \times K_p \times K_c \times W_p \times A \quad (3.1)$$

Where,

WR_c - Computed water requirement (litre $plant^{-1}$)

CPE - Cumulative pan evaporation for three days (mm)

K_p - Pan factor (0.8)

K_c - Crop factor

W_p - Wetted fraction (0.8)

A - Area per plant, m^2

$$\text{Time of operation} = \frac{\text{Volume of water required x Irrigation interval}}{\text{Emitter discharge}} \quad (3.2)$$

Table 3: Quantity of Water Applied Per Plant for Chilli (COCH1)

Crop Date	Quantity Applied Per Plant (lpd)	Duration of Irrigation (min) Each Day	Total Quantity (l) Applied Per Plant Per Stage
Initial Stage (Sep 25 to Oct 14) 1-20 days	0.427	20	1.281
Vegetative stage (Oct 15 to Nov 09) 21 - 45 days	0.223	10	0.669
Fruit setting stage (Nov 10 to Dec 24) 46 - 90 days	0.583	27	6.996
Final stage (Dec 25 to Jan 23) 91 - 120 days	1.078	48	10.78

Fertigation Scheduling

Drip laterals were laid along the length of each raised bed at the centre with the spacing kept at 1.20 m between two adjacent laterals. Fertigation to individual plot in each replication was controlled by a manual regulating valve fixed to the lateral lines to ensure precise delivery of the required inputs thus enabling full control of experimental setup. A dosage of 120: 80: 80 NPK kg ha^{-1} was taken as 100 per cent recommended dose of fertilizer (RDF) and 75 per cent of RDF was phosphorous applied as basal through Super Phosphate. Fertilizer requirement of chilli is shown in Table 3

Table 3: Details of Quantity of Fertilizers Applied for the Plot Area (kg)

Basal Dose				
75 % of RDF- Phosphorous Applied as Basal Through Super Phosphate = 60 x 6.25 = 375 kg ha^{-1}				
Top Dressing				
Stage	**Name**	**80 % RDF**	**100 % RDF**	**120 % RDF**
Transplanting to plant establishment stage (1-10 days)	NPK 19:19:19	0.081	0.102	0.122
	Urea	0.067	0.084	0.101
	SOP	0.029	0.037	0.044
Flower initiation to flowering (10 - 40 days)	NPK 19:19:19	0.163	0.204	0.245
	Urea	0.338	0.422	0.507
	SOP	0.179	0.224	0.269
Flowering to fruit set (40 - 70 days)	NPK 19:19:19	0.081	0.102	0.122
	Urea	0.270	0.338	0.405
	SOP	0.149	0.186	0.224
Alternate day from picking (70 - 120 days)	NPK 19:19:19	0.081	0.102	0.122
	Urea	0.169	0.221	0.153
	SOP	0.089	0.112	0.134

Installation of Drip System and Fertigation Unit

Irrigation water was pumped through 7.5 hp bore well pump and conveyed through the main line of 75 mm diameter PVC pipes after filtering through screen filter. From the main pipe, sub main of 63 mm diameter PVC pipes were drawn. From the sub main, laterals of 16 mm diameter LLDPE pipes were installed at the surface. Each lateral was provided with individual tap control for imposing irrigation. Along the laterals, online drippers were fixed at a spacing of 60 cm. The number of laterals installed was based on the number of rows of crop grown. The discharge rate of single dripper is 4 lph. Sub mains and laterals were closed at the end with end caps. Water soluble N and K fertilizers were used in this experiment. Phosphororus was applied manually as a basal dose. The recommended soluble fertilizers were applied simultaneously in a combined form to the plant root zone. Urea, NPK 19:19:19 and Sulphate of potash were applied through fertigation system

with fertilizer tank and venturi. The fertilizers were dissolved in water in the ratio of 1:5 and the solution was diluted in fertigation tank. The fertilizers were dissolved in water in the ratio of 1:5 and the solution was diluted in fertigation tank. With venturi injectors, water is extracted from the main line, and a pressure differential is created by a valve in the mainline forcing water through the injector at high velocity. The high velocity water passing through the throat of the venturi creates a vacuum or negative pressure, generating suction to draw chemicals into the injector from the chemical tank. The 80 per cent, 100 per cent and 120 per cent recommended N and K water soluble fertilizers was regulated by operating the tap connected at the starting end of each lateral.

Plate 1: Field Preparation

Plate 2: Application of Fertilizer to Drip Irrigation System

RESULTS AND DISCUSSIONS

Effect of Mulching and Fertigation on Biometric Observation

The data on plant height, number of branches, fruit length, fruit girth and green chilli yield at 45, 60, 90 Days After Transplanting as influenced by mulching and fertigation levels. The results revealed that 90 DAT, maximum plant height of 85.46 cm was recorded under 25 micron thickness plastic mulch at 120 per cent RDF (T_3) and lowest plant height of 72.67 cm was recorded for the treatment T_7 (no mulch with 80 per cent RDF). The maximum number of primary branches was recorded in the treatment of 25 micron thickness plastic mulching with 120 per cent RDF level (T_3) which was 7.83 at 90 DAT. The minimum number of primary branches per plant was observed in T_7 treatment of 80 per cent RDF level with no mulch.

Mulching produced more fruits per plant compared to control. A maximum of 128 numbers of fruits per plant was recorded in the treatment of 25 micron thickness with 120 per cent RDF (T_3) and the minimum number of fruits was obtained in treatment T_7. Fruit girth has significant effect on the mulching and fertigation treatments. The maximum fruit girth was observed in the treatment T_3 (3.83 cm) followed by T_6 (3.78 cm) and T_2 (3.72 cm). The lowest fruit girth was observed in the treatment T_7 (3.12 cm).The maximum green chilli (COCH1) length of 13.06 cm was recorded in treatment T_3 of 25 micron thickness plastic mulching with 120 per cent RDF level of fertigation followed by treatment T_6 and the lowest fruit length of 12.25 cm is observed in treatment T_7 of no mulch with 80 per cent RDF level of fertigation. The maximum total green chilli (COCH1) yield of 12.27 t ha^{-1} was recorded under 25 micron thickness plastic mulch at 120 per cent RDF (T_3). The total yield of 11.99 t ha^{-1} and 11.82 t ha^{-1} were recorded for T_6 and T_2 respectively, and the lowest total green chilli yield of 8.91 t ha^{-1} was recorded for the treatment T_7 (no mulch with 80 per cent RDF). The interaction effect of mulching and application of drip fertigation level were significant on the total yield of chilli (COCH1).

The increased yield in fertigation treatments might be due to better availability of plant nutrients and irrigation water throughout the crop growth period under drip fertigation system. This is in accordance with the findings of Gutal *et al*. (1992). Hence the 25 micron thickness black plastic mulch produced higher soil temperature than 50 micron thickness mulch. The difference of 2 to 5^0 C was observed between mulch and non mulched treatments. Mulches increase the soil temperature, prevent soil water evaporation and retain the soil moisture. The adoption of plastic mulching in chillies resulted in increase yields which varied from 20 per cent over control treatments.

Weeds were found only in the unmulched plots and their numbers increased with the increase in fertilizer application. There were 12, 9 and 7 numbers of weeds present in the treatments T_9, T_8 and T_7 respectively.

Water Use Efficiency and Fertilizer Use Efficiency

The total quantity of water applied uniformly to all the treatments was 75.83 litre as per the crop water requirement. The highest water use efficiency of 66.36 kg $ha^{-1}.mm^{-1}$ was recorded in treatment T_3 which is 25 micron plastic mulch with 120 per cent RDF. The lowest water use efficiency 48.19 kg $ha^{-1}.mm^{-1}$ was recorded in unmulched treatment with 80 per cent RDF (T_7). It was because of fewer yields obtained in the treatment. The highest N, P and K fertilizer use efficiency of 109.95 kg ha^{-1},164.94 kg ha^{-1} and 164.94 kg ha^{-1} respectively were recorded in T_1, ie, 25 micron thickness plastic mulch at 80 per cent of fertigation and the lowest N, P and K fertilizer use efficiency of 75.61 kg ha^{-1}, 113.42 kg ha^{-1} and 113.42 kg ha^{-1} respectively were recorded in T_9, ie, no mulch at 120 per cent of fertigation levels. Increased fertilizer use efficiency with the decreased level fertilizer dose through drip was observed. The WUE, NUE of N, P, K in chilli crop is shown in Table 4 and Table 5.

COST ECONOMICS

Among different levels of fertigation and mulching higher B:C ratio was recorded under both 25 micron thickness plastic mulch at 100 per cent RDF (T_2) and 25 micron thickness plastic mulch with 120 per cent RDF (T_3). From figure 4. it was observed that from all the mulching treatments, only treatment T_2 of 25 micron thickness with 100 per cent RDF was economically viable when compared to T_3 since the gross revenue from T_2 treatment exceeded the cost of plastic mulch which gave additional and highest profit to this treatment. All other treatments except T_4 and T_6 gave positive beneficial profits when compared to the cost of plastic mulch used in the treatments. In control plot (T_7) with 80 per cent RDF B:C ratio was 1.82, which is less than the other treatments. From this experiment, it was observed that the crop chilli (COCH1) receiving 100 per cent RDF with 25 micron thickness plastic mulch (T_2) registered results that were economically viable than other treatment combinations.

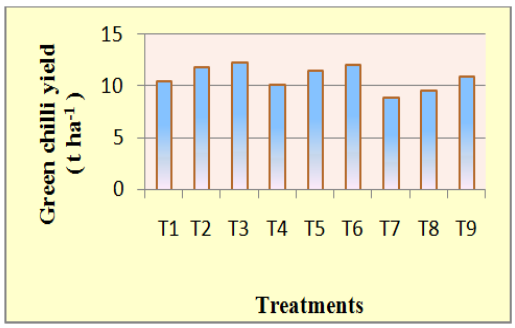

Figure 1: Effect of DF and PM on Green Chilli Yield

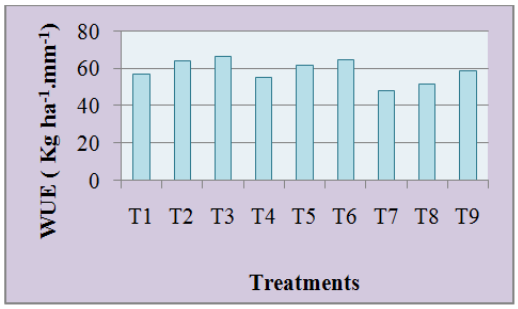

Figure 2: Effect of DF and PM on WUE

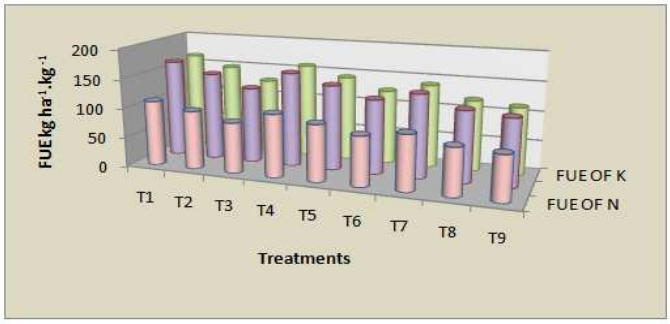

Figure 3: Effect of DF and PM on FUE of N, P, K

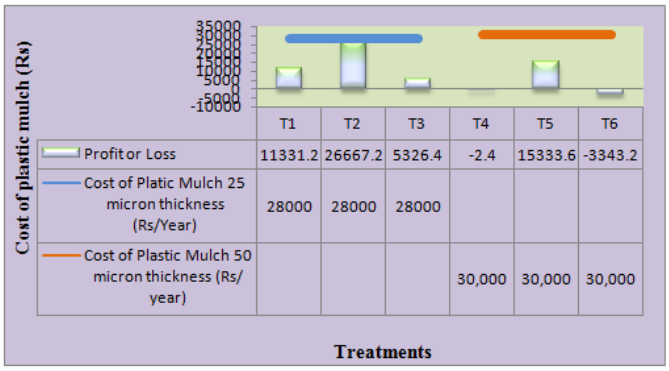

Figure 4: Economic Viability of Mulching

CONCLUSIONS

The maximum total green chilli (COCH1) yield of 12.27 t ha^{-1} was recorded under 25 micron thickness plastic mulch at 120 per cent RDF (T_3). Treatment T_2 of 25 micron thickness with 100 per cent RDF was economically viable and the control plot (T_7) with 80 per cent RDF B:C ratio was 1.82, which is less than the other treatment. When compared to control treatment 20 per cent of chillies yield increases in both drip fertigation and plastic mulching.

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